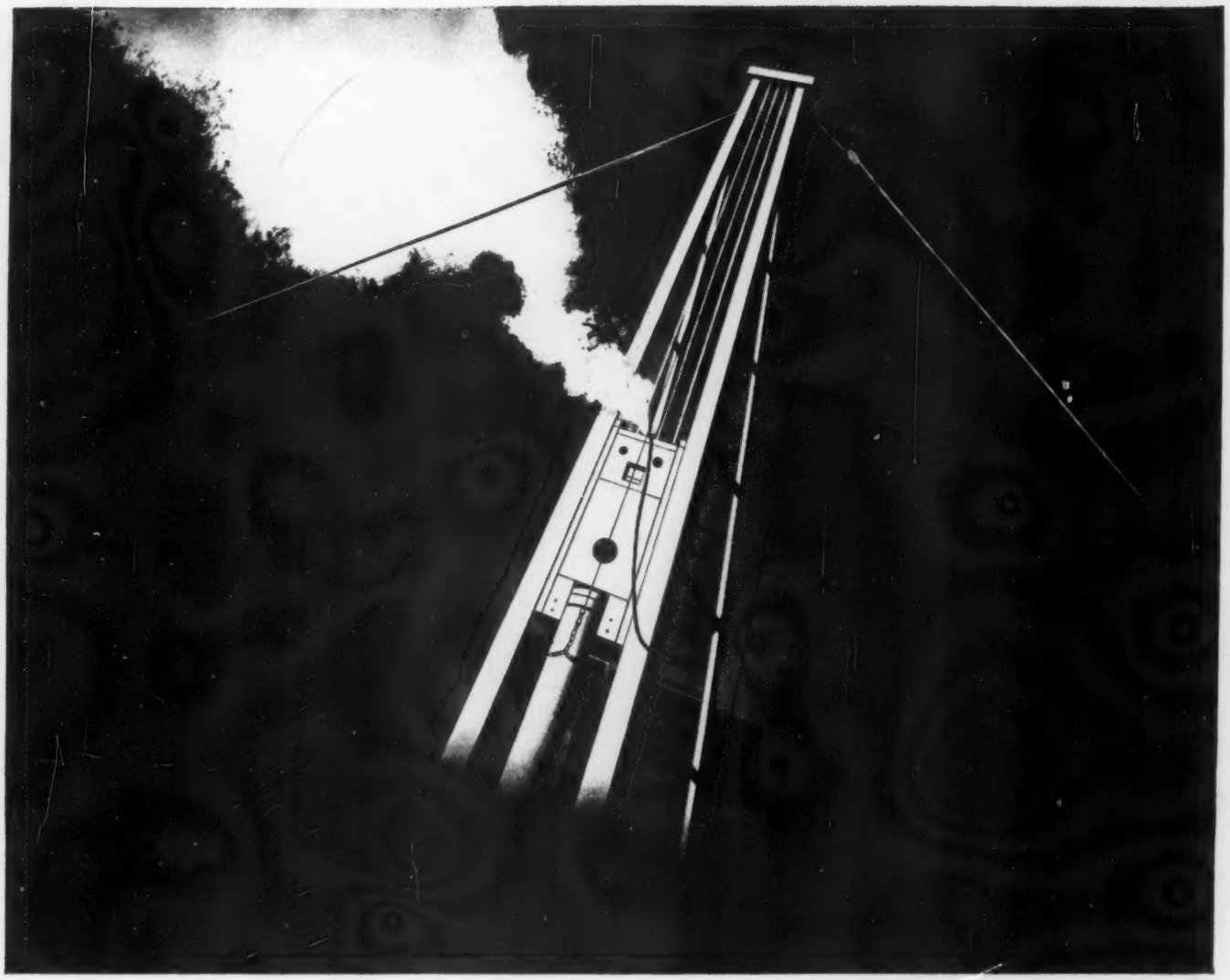
TECH ENGINEERING NEWS

MARCH · 1940



PILE DRIVERS CAN'T CALL "TIME OUT"

When a pile driver goes to work time is generally the essence of the contract, with penalties for non-fulfillment an ever-present threat. Hence the ability to give continuous service under difficult conditions and with a minimum of attention is an essential requirement. That, in turn, depends largely on the choice, for each part, of the material best adapted to the job.

One manufacturer, whose pile drivers have made an enviable record for trouble-free performance, guards dependability by making the ram piston — a vital part — of Nickel-Chromium-Molybdenum Steel. This steel develops to a high degree the particular combination of toughness, strength and hardness, in the heavy sections used, which is necessary to withstand the rigors of the service.

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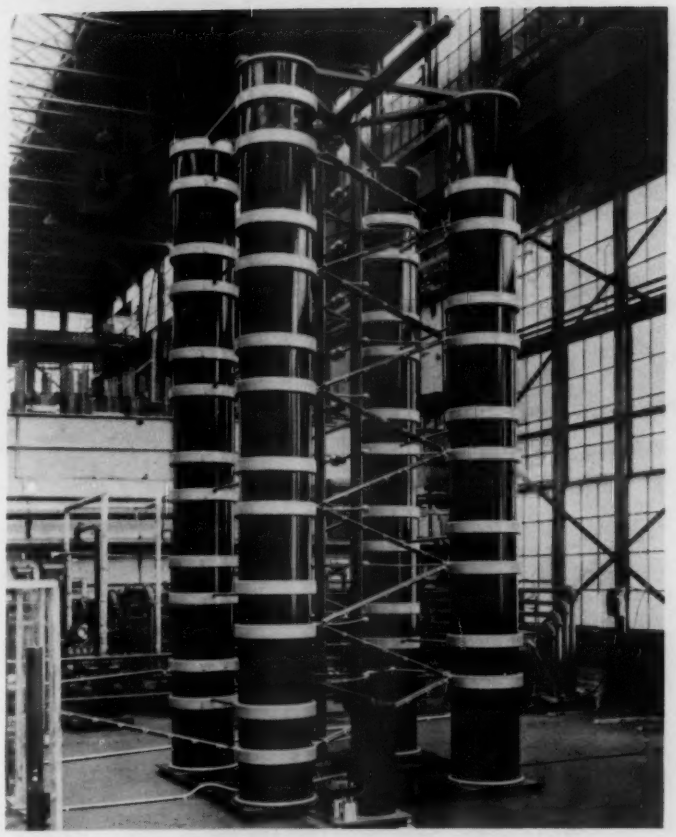

OUR COVER THIS MONTH
A view of the Van de Graaff Generator

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Interior view of Van de Graaff Generator showing scale of mechanism

BARRAGE

SECRETS OF ATOMS DISCLOSED BY MODERN PHYSICISTS

By JEROME T. COE, '42

MEMBERS of the physics department of M. I. T. engaged in atomic research recently announced the discovery of three new radioactive forms of the element indium. The radioactive elements appeared on bombardment of the rare metal with high voltage x-rays produced by the electrostatic generator at the Institute.

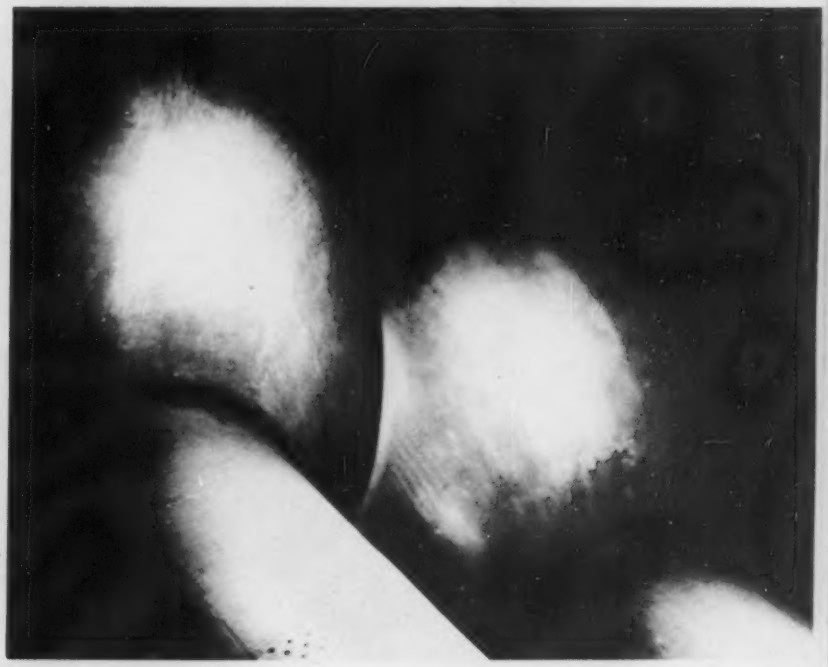
The announcement directs attention to the nuclear research being carried on throughout the world with various types of apparatus, outstanding among which is the Institute's high voltage equipment. Physicists have been studying atomic structure by means of bombardment since 1919, when Lord Rutherford used the gas nitrogen as a target for high-speed particles from radioactive sources. The conception of the atom as a heavy nucleus surrounded by various electron orbits has stimulated investigation of atomic structure. Modern physicists commonly employ high-speed particles to break up atoms into components which may be examined after the barrage.

Atomic disintegration, which is produced in most substances only with great difficulty, occurs naturally in some materials, which are termed radioactive. Naturally radioactive substances transmute from one element to another while giving off various emanations. This phenomenon has been known and investigated since late in the nineteenth century. It was found that uranium compounds, radium, polonium, and a few others gave off radiations of a sort which affected a photographic plate. Investigation showed three distinct types of emanations which were designated as alpha, beta, and gamma radiation. Analysis of the various particles was made by a suitable combination of known electric and magnetic fields, by which the charge and mass of the moving particle were determined. Alpha particles were found to be doubly charged ions of helium, that is, the nucleus of the helium atom carrying two positive charges. Beta rays are electrons, shot from the radioactive substances at velocities which may approach nine-tenths the speed of light.

The paths of these high-speed particles may be observed by the trail of wreckage which they leave in their wake. An alpha particle, for instance, will ionize the air through which it passes. Suitable adjustment of the humidity by varying the air pressure will allow water droplets to form along the ion trail. These "cloud-tracks" may be photographed or observed visually.

To understand the nature of gamma radiation, the reader should be familiar with some of the theory regarding light and similar electromagnetic radiations. There is strong evidence to suggest that light is transmitted in waves. It can at least be assigned a wave length and a frequency. The wave length of the radiant energy determines whether or not it will appear in the visible range. X-rays are radiations of the same nature, but with a much shorter wave length. To tie up the properties of light with the atomic picture of nucleus and surrounding electron orbits, the quantum theory of light was evolved by Planck in 1900. Instead of emanating continuously in waves, light is thought to proceed from its source in bundles of energy known as "quanta." These little bundles are now called photons. The light corpuscles are non-material, but, since they contain energy when traveling at the speed of 186,000 miles a second, they possess a very definite mass. The transmission of light through space seems to be a continuous wave process, although its emanation and absorption can be explained only by the quantum principle. The store of energy in a photon depends on the wave length of light used. A photon of light has a mass of roughly 1/200,000 of an electron. An ordinary x-ray photon, however, has a mass about one-fourth that of an electron.

The gamma rays mentioned in connection with radioactive substances are merely emanations of photons. Since these carry no charge, they alone of the



three emanations are unaffected by a magnetic field. In this process of decay of radioactive material, which goes on with the loss of particles, new elements are formed. Several stages of disintegration are noted, the final product being generally lead.

The modern methods of producing this type of atomic explosions artificially have shown several things: (1) All non-radioactive elements can be transmuted artificially; (2) the nuclei of the atoms of so-called stable elements are complex in structure; and (3) protons and neutrons are among the constituents of an atom nucleus. The various particles which have been discovered in this research process will only be enumerated, since a detailed description of each would be too lengthy. They are generally identified by a mass number, which is the relative atomic weight compared to hydrogen as 1, and the charge which the particle is carrying. The proton of mass 1 and charge 1 is the nucleus of the hydrogen atom. A deuteron is a particle of mass 2 and charge 1, and is the nucleus of the "heavy" hydrogen isotope. The neutron is a neutral particle of mass 1. The common electron and the recently discovered positron are, respectively, negative and positive electrical charges of small mass. The alpha particle has been previously described as the helium ion.

Prominent among the devices used in nuclear bombardment is the electrostatic generator developed by the high voltage research staff of M. I. T. This machine builds and maintains a high electric charge by which small charged particles may be forced to attain very high velocities. The electrical charge is placed on a moving endless belt which carries it to the inside of a large elevated aluminum sphere. It is a well-known fact that all charge placed on the inside of a conducting sphere will appear on the outside. Thus the electricity brought to the sphere will finally build up to a large value on the outside surface.

Many features of the high potential currents which may be produced in this manner make the electrostatic generator particularly suitable for nuclear research. The following advantages are described in a paper by Dr. R. J. Van de Graaff, Dr. K. T. Compton, and Dr. L. C. Van Atta written before the apparatus was completed:

(1) Possibility of obtaining strictly homogeneous beams of electrified particles.

(2) Possibility of accurate focusing which becomes relatively more important as the voltage and therefore the length of discharge tubes is increased.

(3) Elimination of stray radiation which arises in a variety of ways from a discharge tube and generation apparatus operation at unsteady voltages, and which renders difficult the careful shielding necessary to permit the use of the delicate instruments and sensitive amplifiers required in so many applications of these voltages.

(4) Ability to use the ion source to full capacity since the useful voltage is applied all of the time. (Other voltage sources supply current only for very small percentages of the total time.)

(5) Ability to measure the high potentials accurately as, for instance, by the use of null or compensation methods.

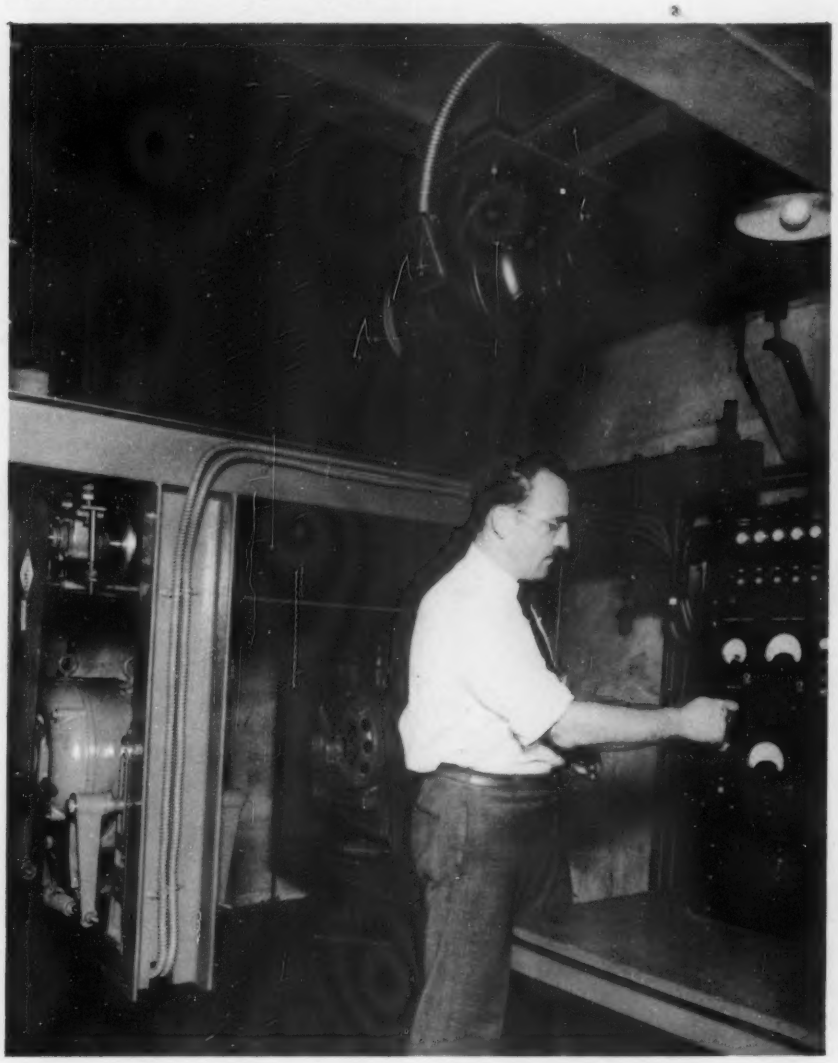
(6) Elimination of breakdown in vacuum tubes due to reversal of the voltage — a phenomenon inherently associated with the walls of vacuum tubes even under the best available conditions of evacuation.

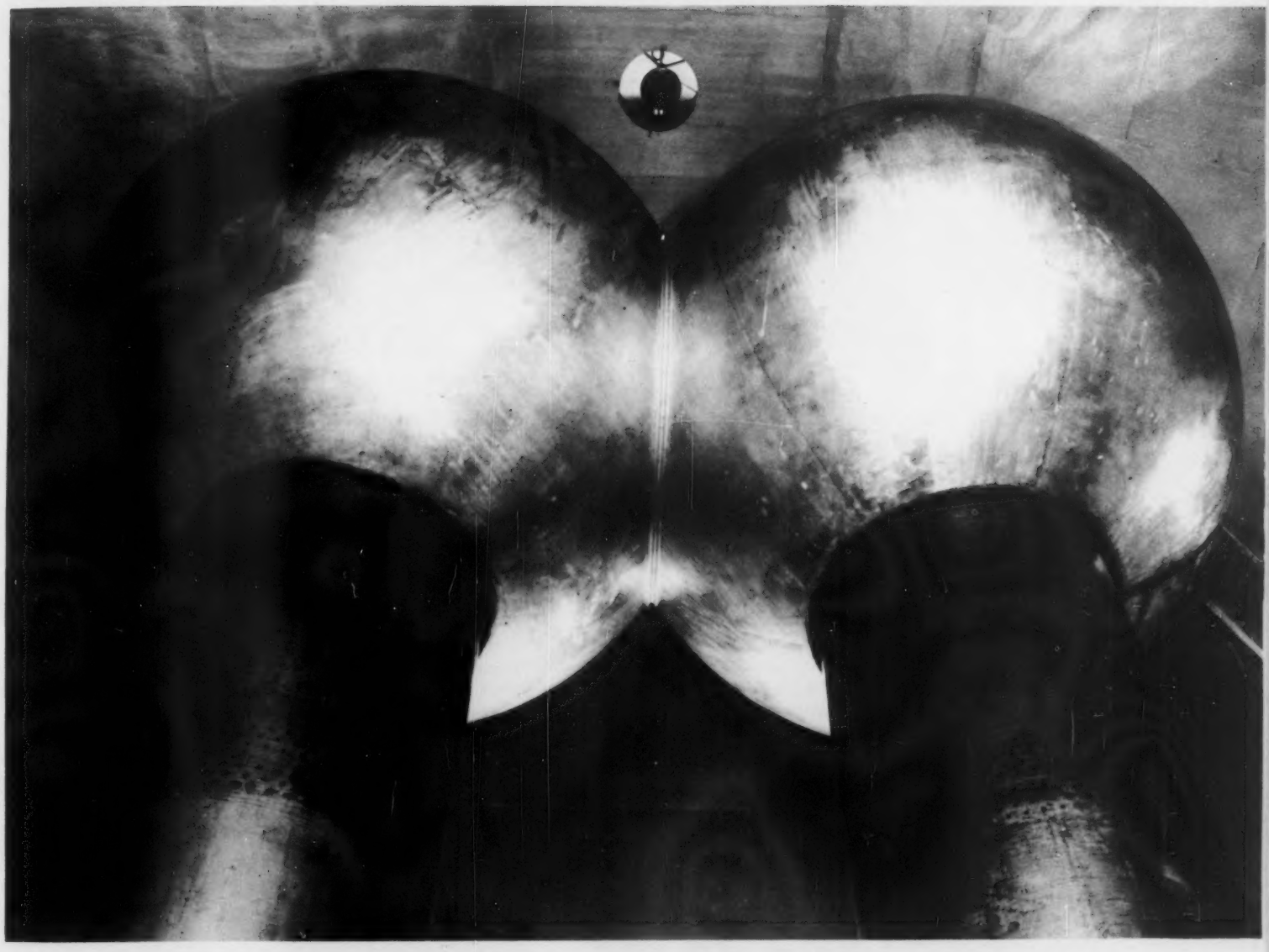
(7) Ability to utilize the advantages of geometrical dissymmetry between positive and negative electrodes in vacuum in such a way that the field is minimum at the surface of the negative electrode, where difficulties from field currents are most serious — an advantage which finds its maximum embodiment when the cathode is a hollow sphere surrounding a central spherical anode.

(8) In a variety of other ways through the elimination of time variations in the electrical conditions of the apparatus.

The present apparatus at M. I. T. differs from the original design developed at the Round Hill Experimental Station in that the two fifteen foot spheres are now combined to make a single terminal. Charge is carried up on three belts, each four feet wide, which may be run at speeds up to 6,300 feet per minute. Inside the other insulating column is placed the evacuated discharge tube extending from the elevated terminal to a target underground. Control of the apparatus is from a distance, so that the operators may not be exposed to the powerful radiations sometimes produced at the target. A charging current of four milliamperes on the belts provides a continuous discharge current of the same magnitude, once the

Down in the "works" of the generator





terminal is charged to capacity. A potential of 2,500,000 volts may be delivered to the spheres in a fraction of a second.

Charge is supplied to the belts by the corona discharge from a 30 kilovolt rectified AC transformer. This source is connected to the lower belt pulley and to a series of fine wires in the form of a comb which spray the charge onto the rubberized cotton belt. The charge is removed, so to speak, by a similar wire comb at the top. Actually, charge of the opposite sign is supplied at the top of the belt system by another 30 kilovolt source grounded to the aluminum spheres.

The vacuum discharge tube is designed so as to have a focusing effect on the beam of positive or negative particles speeding down the tube. Its sides contain about 50 successive steel rings separated by insulated gaps. The electric field caused by the potential difference between the spheres and the target appears in these gaps. The sections of electrical field thus produced give the high velocity to the particle and act as lenses in focusing a concentrated projectile beam.

The source of particles for the bombardment depends on the type of missile desired. Since the spheres can be charged either positively or negatively, particles of either sign may be propelled down the tube. If an electron beam is desired, a heated metal filament is placed at the top of the tube. Electron speeds of about 98 per cent of the speed of light may be attained. A beam of this energy will melt a piece of steel. Bombardment with deuterons, the nucleus of the heavy hydrogen atom, is initiated by passing an electric arc through a tube containing gaseous heavy hydrogen. The ions formed in this process are then propelled electrically down the tube. The generator may be used to provide a source of x-rays by directing an electron beam at a water-cooled target of spun gold. The rays are produced when high-speed electrons strike metal. The kinetic energy of the electron is transformed by the absorbing material, which in turn emits x-ray photons. Neutron bombardment may be accomplished by directing a beam of deuterons at beryllium. The metal becomes an intense source of neutrons.

Research in nuclear physics will continue in the future through the use of the electrostatic generator, the cyclotron, and other devices by which the physicist may force the atom to yield its secrets. The group in charge of the M. I. T. apparatus, Dr. Van de Graaff, Dr. L. C. Van Atta, Dr. C. M. Van Atta, and D. L. Northrup, are continuing investigations of the indium radioactivity and will attempt to discover other unknown reactions within the scope of their atomic artillery. The alchemists' dream has in effect been realized, since the transmutation of every element except one is an accomplished fact.

THE LAST DEGREE

MAGNETIC COOLING USED TO APPROACH ABSOLUTE ZERO

By FREDERICK G. KEYES

MEASUREMENT of temperature appears to be the simplest of operations. Indeed, apparently one needs only to order a "thermometer" from the dealer in scientific supplies, put it in contact with the objects whose temperature it is desired to ascertain, and record the readings. Nothing could be simpler, for if by contrast we measure the volume of a solid, there are several measurements of length required, and a great deal of detail will have to be considered about the exact geometry of the body, its temperature and pressure, for every object expands and contracts in volume under these influences. It may even turn out that time is a factor because of secular changes in the material. Finally, the physical properties of the measuring means must be precisely known and controlled through reference to some standard of length; itself assured through tests to be invariable in time.

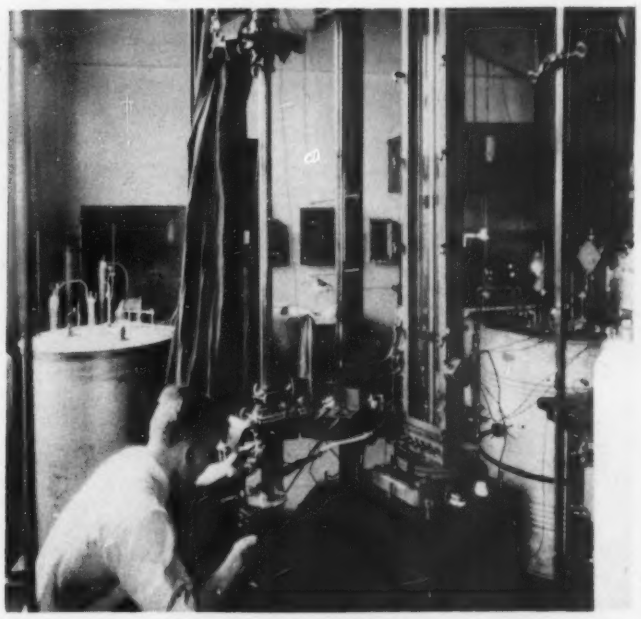


Fig. 1. Equipment for measuring temperatures at M. I. T., unexcelled anywhere

While the measurement of temperature may appear superficially quite simple and direct, like many other operations a really reliable result requires the exercise of much care and attention to detail, acquaintance with which has been accumulated over some two hundred and fifty years through painstaking research.

The amount of care required naturally depends very much upon the object or substance whose temperature is desired and besides precision requirements vary greatly. Thus it would be a waste of time and effort to measure the daily atmospheric temperature to 0.001°, for the variations in this range are erratic and subject to causes beyond human control. However, if one wishes to know the relation between, say the vapor-pressure of pure water and temperature, then the highest attainable precision is sought in temperature measurement. This precision is nevertheless related to the degree to which it is possible to maintain other controls such as temperature steadiness, thermometric reproducibility, pressure measuring precision, and the reliability of primary standards.

Of course as everyone knows the expression of the temperature as so many degrees implies a scale. Thus Fahrenheit degrees refer to the number 32°F for the freezing point of water and 212°F for the boiling point of water under specified conditions. Moreover, mercury is employed in some thermometers and alcohol in others, while besides the expansibility with temperature of liquids, use is made of the electromotive force manifested when the junctions of two wires of different metals or alloys are maintained at different temperatures. The variation of electrical resistance of metals with temperature is used and also the variation of the color of hot bodies at higher temperatures. But all these means give identical readings of temperatures only at the arbitrary points of calibration, and the size of the degree or the indications at intermediate points could only be the same for the various thermometers if nature exhibited a simplicity of design which we have come to doubt as human experience has accumulated. Yet there is a class of thermometers which are so uniformly in agreement that considerable precision in measurement had to be developed before differences were disclosed. These are the thermometers employing what used to be called the "permanent gases"— hydrogen, nitrogen, helium, argon, neon and carbon dioxide. No matter which gas is used, the fractional increase of pressure from the melting point of ice to the normal boiling point of water for constant volume, or the corresponding volume increase for constant pressure, is always closely the same, namely 0.366. This striking fact, together with Avogadro's hypothesis, Boyle's and Gay-Lussac's laws have led to the conception of a scale of temperature expressed by the ideal gas law: $pv=RT$ per mole of pure substance. The size of the degree depends of course on the number of degrees into which the temperature interval between the ice and steam points (or other convenient fixed-points interval) is divided. Thus we divide by 180 to specify the Fahrenheit, and by 100 for the Centigrade degree.

Later work (1890–1939) showed that slight scale differences existed for the different gas thermometers

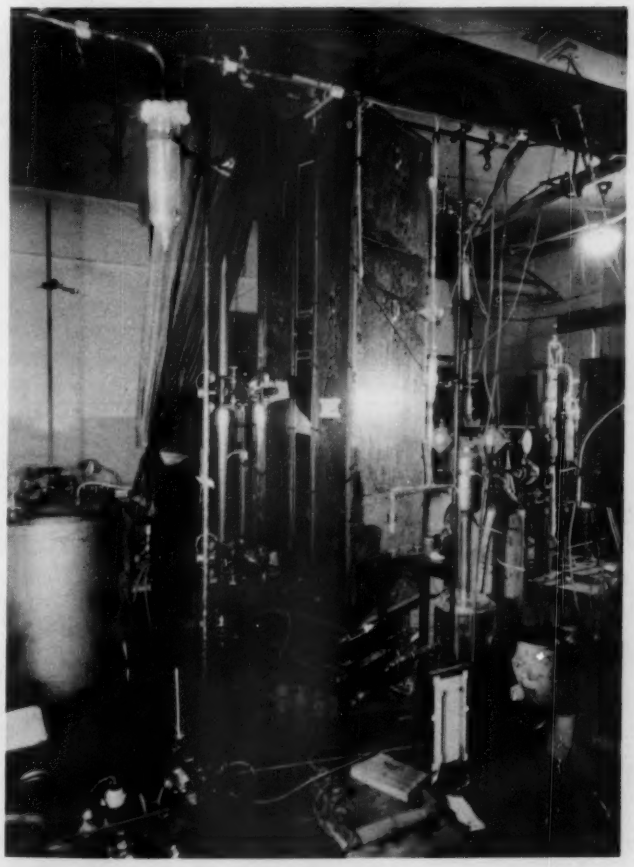
but that each individual gas scale as the pressure was lowered came into ever closer agreement with every other and with the relation $pv=RT$. Through this and other gas properties the very important concept has evolved, that of the ideal gas state. It is realizable in increasing degree as the pressure is diminished at not too low a temperature. The temperature scale given by the ideal gas is therefore unique and actual gases such as hydrogen, nitrogen, and the rare gases provide, as thermometers, such good approximations to the T scale that the differences in the readings for thermometers filled with the different gases amount to small fractions of a degree. A knowledge of the departure of the gases makes possible reduction of any gas scale to that of the ideal gas.

It is clear that the T, or ideal gas scale, on the basis of $pv=RT$ has a lower limit. Thus the expansion for 1/100 of the ice-steam point interval for the ideal gas is 0.00366086, or 1/273.16. Therefore the equation $pv=RT$ may be written $pv=R(273.16+t°\text{C})$, where $t°$C is reckoned from the melting point of ice and the zero on the T scale would be -273.16, or 273.16° below the melting point of ice. How do we get there, and is it an absolute limit?

The Approach to Absolute Zero

Before one may cool bodies with the best economy it is well to understand the laws of thermodynamics, one of the most significant creations of the human mind. The laws are a consequence of, or a generalization based directly on our experiences in the material world. The second law asserts a definite relation between quantities of heat absorbed and rejected in a cyclic process between two fixed temperatures; a relationship independent of the special properties of substances (Carnot 1824). For practical applications the proposition requires a definite temperature scale. The simple assumption has been adopted that the ratio of the heat absorbed at the higher temperature to that rejected at the lower in the sequence of cyclic operations restoring the original state, is the same as the ratio of the temperature of the source from which the heat is absorbed to the sink to which heat is rejected. Since all working fluids give the same efficiency, a low, or strictly approaching-zero-pressure gas may be employed whose equation of state will be $pv=RT$. It turns out then that the temperature involved in the second law statement just given is identical with the temperature given by the ideal gas laws. What do thermodynamics have to offer about the possibility of attaining the zero of temperature — Absolute zero?

Fig. 2. The gas thermometric equipment in operation



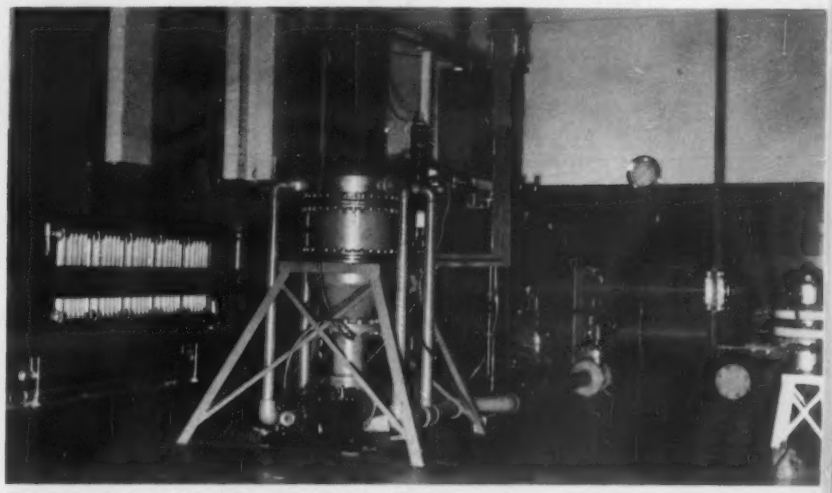


Fig. 3. One of Professor Bitter's large magnets for last degree refrigeration

To begin with, every known gas has been liquefied so that none are known which will not exist in the liquid or solid state at attainable low temperatures. Thus the vapor pressure of liquid helium at 1°C above absolute zero is the order of 0.1 mm. and the practical operation of a refrigerating cycle using liquids or solids offers grave difficulties. By boiling liquid helium, however, well heat-insulated and under reduced pressure, a temperature as low as 0.8°K* has been attained; a temperature estimated by extrapolation from higher temperatures by means of the vapor-pressure-temperature relation for liquid helium based on gas thermometry. Thus it is seen that using the most difficultly liquefiable gas known, and modern pumps, we have been able to approach the absolute zero to roughly 1° by the long-known method of temperature reduction based on the evaporation of a liquid.

Is There an Absolute Zero?

A very natural question is now the following. What reasons are there for supposing that an absolute inferior limit of temperature exists apart from the inferences derived from the development of the ideal gas concept? Also, supposing such a limit does exist, is knowledge possessed indicating the possibility of attaining absolute zero?

The two laws of thermodynamics tell us that in a reversible engine working between the higher temperature T_2 and the lower exhaust temperature T_1, the efficiency or ratio of the work done to the heat, Q_2, taken in by the working substance at T_2 is unity when

* The absolute scale is frequently designated the Kelvin scale, or Kscale, in memory of William Thomson, later designated Lord Kelvin.

T_1, the temperature at which heat, Q_1, is rejected, is zero. Since, as rational beings, we do not expect "something for nothing" the work cannot exceed the equivalent heat absorbed at T_2, and therefore $T_1=0$ is the inferior limiting thermodynamic temperature. In symbols the work, W, is Q_2-Q_1 independent of the working substance and by the laws of thermodynamics

$$\frac{Q_2}{Q_1}=\frac{T_2}{T} \text{ or } \frac{Q_2-Q_1}{Q_2}=\frac{T_2-T_1}{T_2}=\frac{W}{Q_2}=\frac{T_2-0}{T_2}=1 \text{ for } T_1=0.$$

If we accept the two laws of thermodynamics, we are logically led to accept the concept of a temperature zero.

The attainability of absolute zero is something different, however, and the first and second laws of thermodynamics do not say it is strictly unattainable in principle. The mere fact that no practical working fluid is at present available is as immaterial as the necessity of being compelled to draw ideally straight lines to prove a proposition in geometry. There is a body of experience accumulated during the present century which bears on the attainability of 0°K. The principle evolved from the data is now often called the "third law" of thermodynamics, although the designation is unwarranted in fact since it does not stand on the same level as the two thermodynamic laws.

The "third law," or more accurately the entropy principle, is based from the experimental point of view upon the fact that as the temperature is progressively lowered the heat capacity of solids (and liquids) decreases more and more rapidly. This continues until at a temperature peculiar to each crystalline solid an almost catastrophic decline sets in and after about 20°K the heat capacity begins to fall off approximately according to the formula $C_p=CT^3$ where C is a constant. Thus C_p approaches zero faster than does the temperature and the entropy, which in symbols is $S=\int_0^T C_p \frac{dT}{T}$, becomes zero as T becomes zero.*

The two laws of thermodynamics permit no such assertion, for within their circle only differences in the entropy, energy or other thermodynamic quantity are measurable. Of course the entropy could be taken to be zero at any temperature or pressure solely as a convention in dealing with differences. The new principle makes the absolute zero unique with respect to entropy since there we are led to suppose it is strictly zero.

If no means are known whereby the entropy can be changed as the limit of temperature is approached, we perceive that the limit itself is unattainable. This is the conclusion we are obliged to draw from the "entropy principle" or the "third law." It is also evident from a property of liquid helium itself, as follows. Liquid helium transforms into solid helium under pressure in such a way that the equilibrium curve of pressure versus temperature is increasingly independent of temperature below 1°K. Now the latent heat of transition, ΔQ, of liquid to solid is given by the thermodynamic equation:

$$\Delta Q=T\frac{dp}{dT}(v_{liq.}-v_{sol.})=T\frac{dp}{dT}\Delta v.$$

where p is the pressure and $v_{liq.}$, $v_{sol.}$ refer to the specific volumes of the liquid and solid phases. But if p becomes independent of T, then $\frac{dp}{dT}$ becomes zero, and the entropy, or $\Delta Q/T=\Delta S$ approaches zero at a more rapid rate than T does. It is therefore again clear that no thermodynamic process will enable 0°K to be exactly attained using a process involving the two helium phases. (Fig. 3.)

Below One Degree

We have seen from experience that an absolute zero is not only a logical inference but a real limit of temperature 273.16°C below the melting point of ice. The Kelvin scale begins of course at absolute zero but the exact number of degrees which 0°K lies below the temperature of melting ice depends on measurement; the size of the degree Centigrade by agreement being 1/100 of the temperature interval between melting ice and boiling water under one atmosphere of pressure (0.76 meter of mercury at 0° in a gravitational field of 980.665 dynes). The mean value of the number of degrees 0°K is below the ice point, from over a hundred determinations is, within experimental uncertainty, 273.16.

The knowledge about heat capacities and other

(*Continued on page 208*)

* Helium is still liquid at 0.8°K and solidifies at this and lower temperatures only under considerable pressure (25 atm.). Its heat capacity however also goes toward zero as T becomes small, as in the case of solid helium.

Fig. 4. *Liquid helium exists as two varieties, I and II. Liquid II conducts heat thousands of times better than copper in contrast to I, an ordinary liquid. The solid exists only under pressure no matter how low the temperature*

Fig. 5. *An entropy-temperature representation for the paramagnetic salt, iron ammonium alum, if Curie's law held exactly. The normal field free case is marked H=O.*

Fig. 6. *An actual entropy-temperature representation for a paramagnetic salt such as iron ammonium alum showing how the magnetic cycle reduces the temperature*

Fig. 4

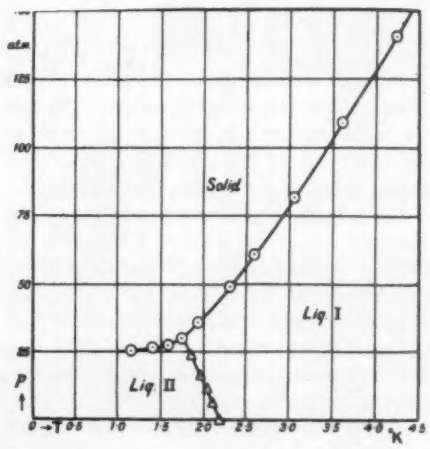


Fig. 5

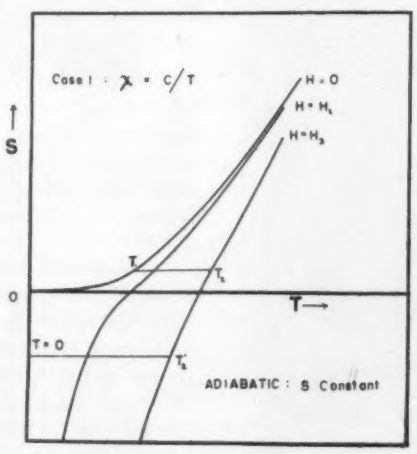
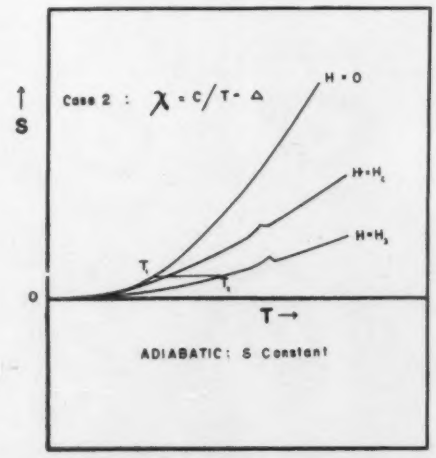


Fig. 6



Underwriters' Laboratories, Inc.

LEST INDUSTRY FORGET

LABORATORY RESEARCH QUESTIONS THE SAFETY OF INDUSTRY'S PRODUCTS FOR THE CONSUMER

By B. P. CALDWELL, JR.

ASSISTANT SECRETARY UNDERWRITERS' LABORATORIES, INC.

HONOR, fame, and sometimes fortune have been the rightful awards of many of the engineers who developed the marvels we enjoy in this scientific age. Less romantic, and therefore less frequently thought of, but nevertheless highly important, have been the contributions to humanity made by other engineers who later helped "take the bugs out" of revolutionary inventions by perfecting them, extending their usefulness, and making them safe.

The mechanization of industry and the development of innumerable labor-saving devices which have taken place since the turn of the century, have resulted in the introduction of *potential* hazards to life and property which were unknown in the 1800's.

Progress and technological development have introduced many new problems for the safety engineer. Some of the more important factors are the widespread use of electricity, the concentration of great stores of combustible merchandise made possible by the advent of the "skyscraper" and the mammoth warehouse, greater speeds in transportation, and the universal use of petroleum and its derivatives.

It is natural that such work should have fallen to the engineer, for the orderliness of mind and the special knowledge resulting from his formal technical training admirably equip him for the work of helping to make these things safe for the average person to use. Much effort is expended to see that *potential* dangers do not become actual hazards.

That this job has been done well is attested by the generally enthusiastic reception of nearly every new invention and development as well as by the fact that today we use and enjoy many modern luxury-affording, labor-saving devices, usually without the slightest thought of danger or fear of harm.

One organization which has played an important part in this work of "helping to make things safe" is Underwriters' Laboratories, Inc., organized in 1894 for service and not as a profit making company. The organization's goal is the reduction of losses of life and property, and its work is the examining and testing of products which have, or may have, some relation to life, fire, accident, or crime hazards.

The products investigated are submitted voluntarily by manufacturers to one of Underwriters' Laboratories' testing stations in Chicago, New York, or San Francisco. Consideration of certain products which undergo examination in the Laboratory will give the reader some idea of the range of research and the responsibility which is assumed in the work. Fire prevention research embodies a study of fire extinguishers, alarm systems and building material. Accident prevention items which are submitted for approval vary from window cleaners' safety belts to safety stair treads. An automotive department examines the design of passenger cars at the factories before they are put into production, and, by carefully checking fuel, ignition, and exhaust systems, this department helps eliminate possible fire hazards. The lives of robbers, thieves, and hold-up men are made unhappy by the Laboratories' burglary-protection engineers who work on safes, alarm

(*Continued on page 212*)

[THE START]
Technology Review

SUPERHIGHWAYS WON'T WORK!

RECENT SURVEYS POINT TO NEW CONCEPTION OF TOMORROW'S ROADS

By HARVEY FREEMAN, '43

A future four-lane highway

Future belt-line near Baltimore *Public Roads Administration*

THE history of highway development in the United States since the introduction of the motor vehicle has been a record of attempts by the roadbuilder to meet the demands of the steadily improving motor car. This improvement, in both highways and cars, is represented most graphically by a comparison of the vehicles of thirty years ago and the amazingly powerful cars of today.

Though the roadbuilder may well boast of past accomplishments, further highway development is needed to keep pace with present and future demands. Increased traffic traveling at increased speeds necessitates highways of greater sight range and better alignment. Many roads built twenty years ago should be reconstructed to meet present-day needs, since most of them are serving where traffic and population are most dense.

Picture motor traffic in the country moving at speeds double those of past years with no congestion and with vastly improved safety. That is what the highway engineers have blueprinted for us for 1960. It is a big order, but the biggest part will be the junking of old ideas and old methods which have survived from the days of the horse-drawn carriage, and the substitution for them of strictly scientific planning.

This "blueprint" is laid out in a report just submitted to the Senate by the United States Bureau of Public Roads. The findings, built up on the most minute and detailed count of all the traffic factors on thousands of miles of highways, are simple and direct:

1. Trunk-line, toll-financed, super highways across America will not work. Traffic just does not move that way.

2. Toughest, and perhaps the most important job is to get vehicles into and out of cities, rather than around them. Most people are headed for town.

3. Next on the order of business is a thorough modernization of a primary system of about 27,000 miles of highway; a network that would take 12.5 per cent of all the highway traffic on less than one per cent of the road mileage. A key service for national defense as well as ordinary traffic.

4. Continued improvement of the remainder of the highway system, with special attention to elimination of hazards such as grade crossings, is important.

5. More development of secondary and country roads with future construction linked to land utilization is another necessity. Roads must go where the land promises to support the population.

This is the result we obtain from the "blueprint." The method is, of course, another matter. Unless present controlling methods are dispensed with, the job cannot be done. The acquisition of land is of cardinal importance, and virtually nowhere in the country can public authorities acquire land to be held for use in the future.

When an artery has to be widened through a city the pains and expense become almost unendurable. The classic example occurred in Detroit where it took ten years and ten million dollars to secure land for a road widening project that cost about one million.

The Bureau of Public Roads proposes a single, sharp, and direct cure for the problem. Local governments do not have and will not have the funds needed to acquire land for the orderly development of traffic-ways for the future. They are prevented by law or other conditions from acquiring enough land to protect both the free-way and the adjoining property.

So, the Bureau proposes that the Federal Government create a land authority to acquire wide strips for both city and country development, and lease them to the states and cities on a basis that will return the investment over a period of many years. Also needed will be authority to control the right of access to the highways, to end the practice of cluttering a main artery with unsightly stands which add to traffic hazards.

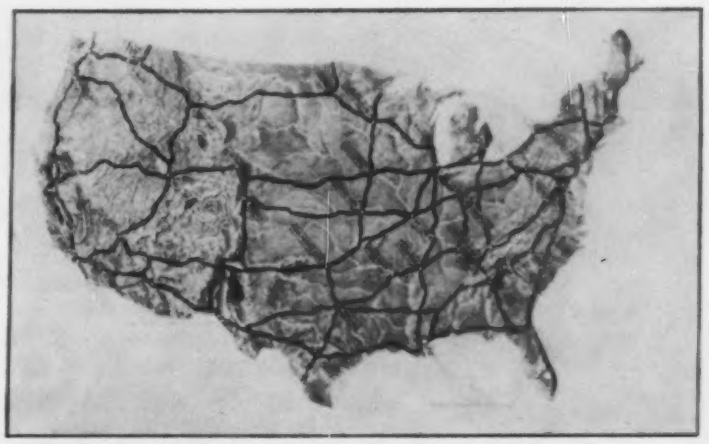
Approaches to cities, where the traffic is the densest, need divided four-lane roads, separated from cross-lane traffic by means of overpasses. Some new road locations will be required, but in most cases existing routes can be maintained.

Only a relatively small amount of highway mileage is going to call for a greater than two-lane width. Most roads carry only a light stream of traffic which can be well spaced out. The troubles of these roads, however, are very real and also spring out of right of way conditions. They were built for slower and fewer vehicles, and in the main still suffer from excessively short curves, excessive grades, and inadequate sight distances for which drivers must plan their speeds, stops, and passing operations.

So, without becoming luxury boulevards, these roads must acquire modernity to keep in step with the evolution of the vehicles that use them.

A highway department must be continually alert to keep abreast of the times. New developments in construction, maintenance, marking, and design are constantly making their appearance. Highway lighting in heavily congested areas, signalization of busy intersections, separation of grades at others, and highway delineation by means of reflectors on the shoulders of the road are counted among the developments of recent years. Some of these may appear to be merely refinements; but we must remember that the refinement of today may be demanded by the public tomorrow.

Highway construction will have to continue as long as we have the motor vehicle. Highway work represents probably the most economical use of the tax dollar that can be made. The benefits to be derived cannot be measured alone in the amount of labor employed, which in itself is an important item these days; there is also a tremendous benefit to the community in the years to follow.



A proposed system of superhighways

Except for education, there are few items in the budget of public funds, so well justified as the expenditures for an adequate highway system. There are few people, if any, who question the dividends paid by the highway dollar in the past generation. And there will be little question of dividends paid in the future, if state, national, and county highway officials continue along the high plane of their past efforts.

EDITORIALS

PHYSICIST AND PHYSICIAN

Installation of the new one million volt x-ray generator at the Massachusetts General Hospital marked the completion of another stride forward on the part of the Institute. The efforts of Dr. Trump and his associates have gone far toward producing a more efficient weapon for attacking one of the world's most insidious enemies — cancer.

Since the day when the physicist and the doctor agreed to use the x-ray tube as a substitute for the radium ray, development of the desired tube and equipment has proceeded steadily. The effective instrument which has thus come about develops healing radiation with greater economy and efficacy and in a safer manner. Viewed as a part of this development, this latest contribution of the Institute can be counted as important; however, as an exemplification of the dependence which exists on the part of the physician toward the physicist, one may consider the step as being of even more significance.

As a suggestion for further work on the part of the physicist many doctors declare their faith in the possibility of using high-speed electrons in the treatment of cases involving malignant tissues. Here again the Institute has its best foot forward, in view of the research carried out involving the high voltages necessary in the production of the electron ray. The effect of this high-speed particle is considered even more satisfactory than the benefits derived through x-ray emanation.

Application of other scientific principles promise a magnification of the physician's perception in his diagnosis of ailing conditions in the body and additional strength in his battle against the agents which transmit disease. The contribution of the physicist to the development of the microscope is particular evidence of the part he plays in aiding the sight of the physician. Hope for arriving at the physician's requirements for this instrument lie in the success of the physicist's light-wave research.

A more imperceptible form of experimentation is the study of those minute electric currents which flow through the body. The physicist's attempt to utilize these currents in an analysis of the nervous system suggests the possibility of a further understanding concerning the patient's state of health. By just such a method, medicine may effect an insight into the physical feelings which govern a person's life.

Consideration of this bond of dependence which every day brings medicine further into the field of science should impress and challenge the student. That the faculties of science are directed toward saving and lengthening human life should be a happy thought to those who are struck by the futility of the efforts which many scientists spend in search of more destructive materials of war.

SCIENCE AND SAFETY

Recent programs designed to lower highway accidents have impressed upon the public mind the three effective points of attack against the problem of automobile safety. These three main points are education, law enforcement, and engineering. Education, which involves instruction in the attitudes of mind, driver habits, and technique, is most effective when given under expert supervision. The principal agencies which enforce the codes of good driving are the police and the courts. The combined efforts of these two agencies have left little room for criticism. The engineers and scientists are contributing their part to the solution of the problem by attempts to improve the automobile itself so that it will fit the conditions of present-day highways.

With 1940 automobiles now on the highways, the American public is enjoying the benefits of the new high-test safety glass, a scientists' contribution to driving safety and comfort.

For this development the chemist has supplied the "sandwich filler," a new plastic which distinguishes this new safety glass from those types previously used. Although the new plastic is made in several trade types, these types all have one common chemical property — polyvinyl acetal resin. This main ingredient distinguished the high-test plastic from the cellulose nitrate and cellulose acetate plastics, which were the first two fillers to be used. In spite of the fact that the several manufacturers may use different "plasticizers," the characteristics of the resulting filler in each case are the same.

Polyvinyl was developed because scientists foresaw the possibility of a plastic which would be stronger and more pliable at all temperatures, and which would cling to glass under all conditions. The new plastic holds to the surface of glass so well that no adhesive material is required in assembling the "safety sandwiches." Polyvinyl is pliable even at low temperatures and has considerable tensile strength after its elastic limit is reached. The new glass, when broken by hammering, may be rolled up like a rug without the glass particles leaving the plastic.

The blurring and distortion resulting from an optical defect in the original safety glass, which tended to make the eye astigmatic, is completely eliminated in this latest development. "Looking through safety sheet glass causes a 62 per cent greater loss in visual acuity after three hours of driving than looking through polished plate safety glass," reported Dr. A. H. Ryan, Chicago physiologist.

Six years of research and six million dollars are represented by the high-test laminated safety plate glass which has been made available to the automobile manufacturers; and the project has been carried out in such a manner that the safer, clearer product will benefit motorists at no additional cost.

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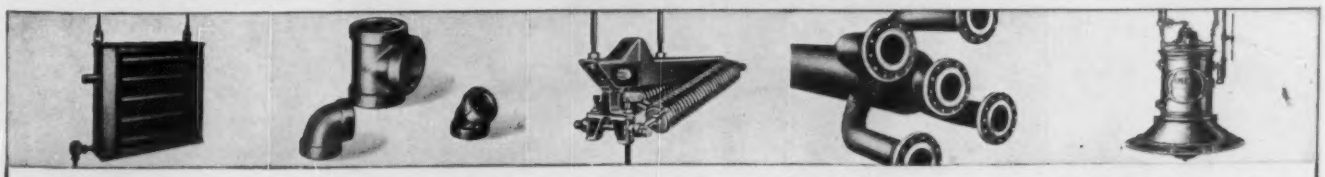

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THE LAST DEGREE

(*Continued from page 202*)

properties leads as we have seen to the further conclusion that this exact limit, 0°K, is unattainable by any known process. Also mechanical thermodynamical processes appear to have enabled us to come no closer to 0°K than roughly one degree. How then may a part or most of the last degree be traversed? Some may ask — having come $\frac{272.16}{273.16}$ of the way from melting ice temperature, why bother about only $\frac{1}{273.16}$? The answer to this is that the shadow of 0°K is still a long way off for we must look upon the melting point of ice as 273.16 times as high as 1°K, and 1°K as one hundred times hotter than within 1/100 of absolute zero. Besides, human curiosity would never remain satisfied as long as the last degree remained unexplored. We may be sure that a rich store of interesting phenomena lies within the last degree.

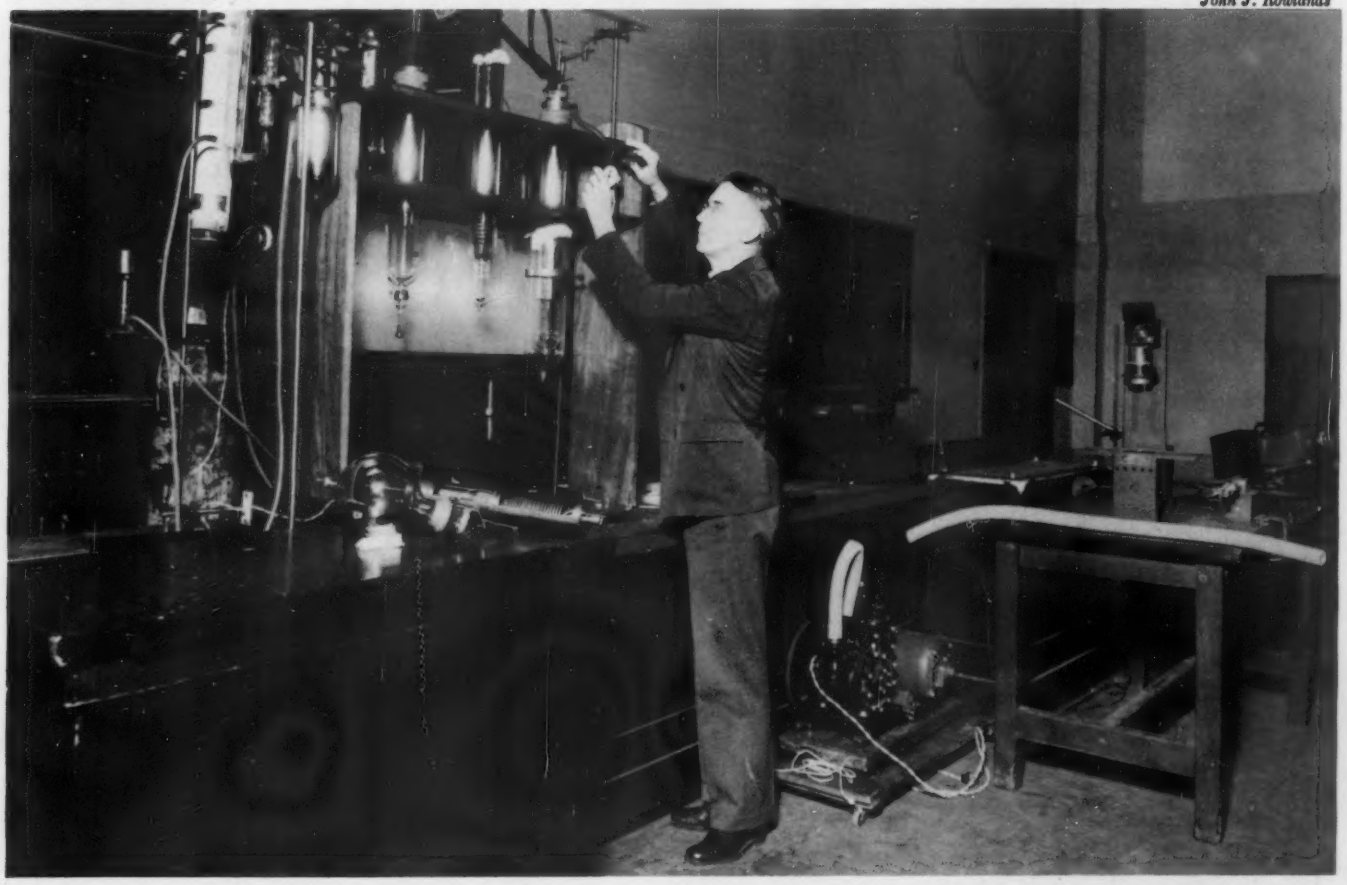
About 1926, W. F. Giauque at the University of California Chemistry Department and Professor Peter Debye (Dutch by birth) at the University of Leipzig, Germany, independently had an inspiring idea. It had long been known that the energy of substances changes when brought into a magnetic or electrostatic field. Volume changes occur and heat is absorbed or evolved. This means that if the electrically or magnetically sensitive substance is thermally isolated so that heat can neither escape nor enter it, the imposition of an electric or magnetic field should cause a change of temperature. Suppose for example that a piece of nickel is so manipulated that it can be placed in contact with a heat reservoir at T°K or heat isolated at will. With the nickel in contact with the reservoir apply a magnetic field. There will be a temperature rise and heat will flow to the reservoir but the nickel will gradually come to equilibrium at T°. Now isolate the nickel and cut off the field. The nickel will of course return to its original state and since it is insulated, heat will have to be derived from the sensible heat of the nickel itself with an attendant drop in temperature. The effect is very small at room temperatures but it has been detected at the temperature (356°C) where the permanent magnetism of nickel vanishes. (Curie point.)

Years ago, in the 1890's, Pierre Curie found that many salts were attracted (paramagnetic salts) to the poles of a magnet and that the induced magnetism, I, per unit value of the magnetizing field, H, or the susceptibility, $I/H=\chi$, varied inversely as the absolute temperature, *i.e.* $\chi=C/T$; Curie's law. Now it is seen that as T grows smaller, χ increases and indeed very rapidly as T becomes very small, provided χ is strictly proportional to the inverse temperature.

Thermodynamics may be applied to the magnetic relationships of the paramagnetic salts such as $(NH_4)_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24\ H_2O$, $K_2SO_4 \cdot Cr_2(SO_4)_2 \cdot 24\ H_2O$, $Ce(C_2H_5SO_4)_3 \cdot 9\ H_2O$ and salts of the rare earths amongst which gadolinium sulphate was one of the first used. The behavior of the salt in the field must be reversible to apply the two laws, and in this case it may be shown that the change of entropy of the salt with the applied field, $\left(\frac{\partial S}{\partial H}\right)_T$, at a fixed temperature is equal to the

Dr. Frederick G. Keyes, Head of the Department of Chemistry at the Massachusetts Institute of Technology, working on the low temperature apparatus with which he has demonstrated the transformation of oxygen and hydrogen into liquid and then the solid form

John J. Rowlands



LIGHT-WEIGHT TRAINS MAKE MONEY—AND

BUDD-BUILT TRAINS MAKE THE MOST!

AN impartial report* prepared by a well-known firm of consulting engineers shows that every light-weight train has proved to be a sound investment. But the best record was made by the *Denver Zephyrs,* stainless-steel streamliners of the Burlington Lines, which produced the greatest revenue of all of these trains during the year ended June, 1939. Gross revenue from the *Denver Zephyrs* was $2,077,444. Net earned income was $1,530,155, or 73.6 per cent of the gross. These trains, complete with sleeping equipment, were built by Budd in 1936.

This report also revealed that the light-weight, stainless-steel trains built by Budd produced the highest average ratio of earnings for the year—with a ratio of net earnings to gross revenue for all Budd trains of 61.3 per cent.

An outstanding success was the Sleeper-Coach train, created by Budd and introduced when the de luxe chair-car *El Capitans* went into service on the Santa Fe in February, 1938. Gross revenue for the *El Capitans* for the year ended June, 1939, was $907,423. Several trains of this same type are now running to full capacity in other parts of the country.

These records give further evidence of the long-term investment value of Budd-built trains. Budd light-weight stainless-steel streamliners were not designed and built to catch a passing fancy. They are built for the long pull—constructed throughout of stainless steel, the strongest structural material known, and fabricated by the exclusive SHOTWELD** process. They have proved conclusively that *they pay,* both by their successful performance under all operating conditions and by their ever-increasing popularity with the traveling public.

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THE LAST DEGREE

(*Continued from page 208*)

change of the induced magnetization, I, with temperature, $\left(\frac{\partial I}{\partial T}\right)_H$. Integrating, we have the equation following,

$$S=f(T)+\int_{H_1}^{H_2}\left(\frac{\partial I}{\partial T}\right)_H dH \qquad (1)$$

where $f(T)$ is the term $\int C_p \frac{dT}{T}$ a function of temperature. If the salt is magnetized at low enough temperatures $f(T)$ might be neglected. However, C_p for some of the paramagnetic salts after coming to a minimum value at 2 to 3°K rises to a value 4 to 6-fold the C_p magnitude at the minimum, passing afterwards through a maximum at 0.02 to 0.04°K, thereafter descending to 0°K.

Curie's law as originally given is $\chi=\frac{C}{T}$. This is very interesting, for since $\chi=\frac{I}{H}$ we may integrate Equation (1) and obtain

$$S=f(T)-\frac{C}{2T^2}(H_2^2-H_1^2) \qquad (2)$$

This equation means that at 0°K the entropy is negatively infinite in a finite field. The conclusion is not correct at low temperature, or at least inconsistent with the entropy principle. A more precise knowledge of susceptibility as a function of temperature has however led to the empirical formula $\chi=\frac{C}{T+\Delta}$ where Δ may be constant or a temperature function and of either sign. If Δ is negative, then χ becomes infinite for $T=\Delta$ and an anomaly exists in the χ, T relation. Enough work has been done at very low temperatures to show that the susceptibility in relation to temperature is not as simple as the above formula would indicate although the high temperature behavior (50°K and higher) is well represented. It is probable that Δ has no easily defined physical meaning.

Suppose with the information stated we now follow in our imagination the effect of applying a magnetic field to a paramagnetic salt following the sequence of operations. (*a*) The substance is placed in a container along with a small amount of helium to promote heat transfer, and exposed to a magnetic field H_2 at a temperature of say 2°K. (*b*) The heat of magnetization is removed by conduction. (*c*) The conductive helium gas is pumped away and when thermal isolation is complete the field is reduced to H_1 and the temperature measured by some means. It is instructive to suppose two kinds of substance, (1) a "Curie" substance (Fig. 2) following the law $\chi=\frac{C}{T}$, and (2) an actual substance (Fig. 3) for which $\chi=\frac{C}{T-\Delta}$ is a fair representation of the magnetic behavior. For case (1) we have already equation (2).

Evidently for values of T low enough the second term of the right hand member of equation (2) will be large enough to make the entropy negative as shown in Fig. 5. Starting with field $H=H_3$ or $H=H_2$, annihilation of the field lowers the temperature to T_1, but if negative entropies are really possible, demagnetization at low enough initial temperatures must bring the temperature to absolute zero; no one believes this.

In case (2), Fig. 6, taking $\chi=\frac{C}{T-\Delta}$ we have an anomaly at $T=\Delta$, if Δ is positive and constant. We now have the equation for entropy as follows:

$$S=f(T)-\frac{C}{2(T-\Delta)^2}(H_2^2-H_1^2) \qquad (3)$$

The consequence is demagnetization at constant (S) from various field values can lower the temperature progressively but without making it possible to actually attain 0°K. It has been possible however to reduce the temperature to 0.005°K subject to possibly a 25 per cent error.

Last Degree Thermometry

A question arises about the measurement of temperature below 1°K, for even helium gas has insufficient pressure below 1° to serve as a gas thermometer. Electrical resistance for pure metals is moreover temperature independent, but phosphor bronze has been used with some success. Such a thermometer's indications must however be interpreted on the thermodynamic scale and leads to the heart of the problem: namely to find a substance whose properties permit its use in a reversible thermodynamic cycle. It is natural to suppose the paramagnetic salts themselves might be useful employing a magnetic cycle, and at present this seems to be the most promising idea.

The procedure is direct enough although the measurements involve special difficulties. Suppose we take the symbol Θ to represent an arbitrary temperature scale obtained by using the variation of resistance of some alloy, phosphor bronze, calibrated for example in the liquid helium region where thermodynamic temperatures (1° to 5°) are known from gas thermometry with an accuracy of perhaps one or two per cent. The readings of such a thermometer could be represented by an empirical function which would give the thermodynamic temperature over the range of calibration but below, say 1°K, the readings must be assumed arbitrary because extrapolated. In this lower range any observed phenomena would be designated as occurring at temperature Θ instead of T, for the indicated temperature would not necessarily be the thermodynamic temperature.

The problem of finding the relation between Θ and T, say $T-\Theta$, depends on relationships following from the application of the general thermodynamic to the magnetic cycle of a paramagnetic salt. It can be shown that the magnetization must be determined in relation to the arbitrary scale Θ as a function of the magnetic field H. The quantity is $\left(\frac{\partial I}{\partial \Theta}\right)_H$. Two other quantities are also required as follows: The heat capacity or specific heat of the salt is defined as the amount of heat required to raise the temperature 1°C. This quantity must be determined in terms of the Θ scale and also in a magnetic field. The quantity may be designated $(C_p)_H^\Theta$ the superscript recalling that the specific heat, (C_p), has been measured on the Θ scale and the subscript H denoting that the quantity has been obtained in a constant magnetic field of a definite magnitude. The remaining quantity is the adiabatic change in temperature of the salt when a magnetic field is applied $\left(\frac{\partial \Theta}{\partial H}\right)_S$. Having these measured magnitudes they can be shown to stand in the following relationship to the T scale.

$$\log\frac{T}{T_0}=-\int_{\Theta_0}^{\Theta}\frac{\left(\frac{\partial I}{\partial \Theta}\right)_H d\Theta}{(C_p)_H^\Theta\left(\frac{\partial \Theta}{\partial H}\right)_S} \qquad (4)$$

It is now clear that given a paramagnetic salt which will perform reversibly in a magnetic thermodynamic cycle, we may be quite certain of establishing true thermodynamic temperatures. Really the great difficulty, having settled the question of reversibility, is to find a suitable (*i.e.* permanent and reproducible) secondary Θ thermometer. This is indeed one of the immediate great difficulties.

Of course if a really perfect Curie substance existed, the problem of thermodynamic temperatures would be very easily solved, for in this case the thermodynamic temperature T would be given by $\frac{CH}{I}$ where C is Curie's constant in $\chi=\frac{C}{T}$. No one has any confidence that such a substance exists — at least over any considerable range of temperature. There are however preferred salts which approximately follow Curie's law and in due course the technique of the necessary precise measurements will be evolved. We may be certain that the labor expended will in the end lead to new vistas for the inspiration and well-being of mankind.

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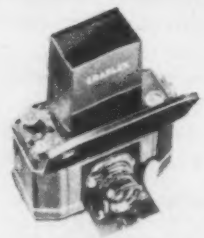
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LEST INDUSTRY FORGET

(*Continued from page 203*)

systems, tear gas, bullet-resisting glass, and steel to see that these are sufficiently well made to provide adequate protection.

A corps of electrical engineers is continually at work on conduit wire, switches, fuses, circuit-breakers, and the other units of permanent wiring systems of buildings of all kinds. Numerous types of electrically operated industrial equipment, which will vary from the hair waving machines for beauty parlors to the largest electric advertising signs atop the buildings on Boylston Street, also are submitted to the Laboratories for an examination of the fire and shock hazards involved. In addition, almost all types of domestic electrical appliances are examined by the Laboratories' electrical engineers to help eliminate as far as is commercially practicable the dangers to the user which may come about from normal or abusive use.

Explosions and fires from gas and oil equipment — oil burners, gasoline filling station pumps and tanks, acetylene generators, and many other products are the concern of the engineers in another department.

Spontaneous ignition of dust-laying sweeping compounds, motion picture film and still film, the flash-points of oils, paints and varnishes, and even the ignition temperature of household matches occupy the attention of chemists and chemical engineers at Underwriters' Laboratories.

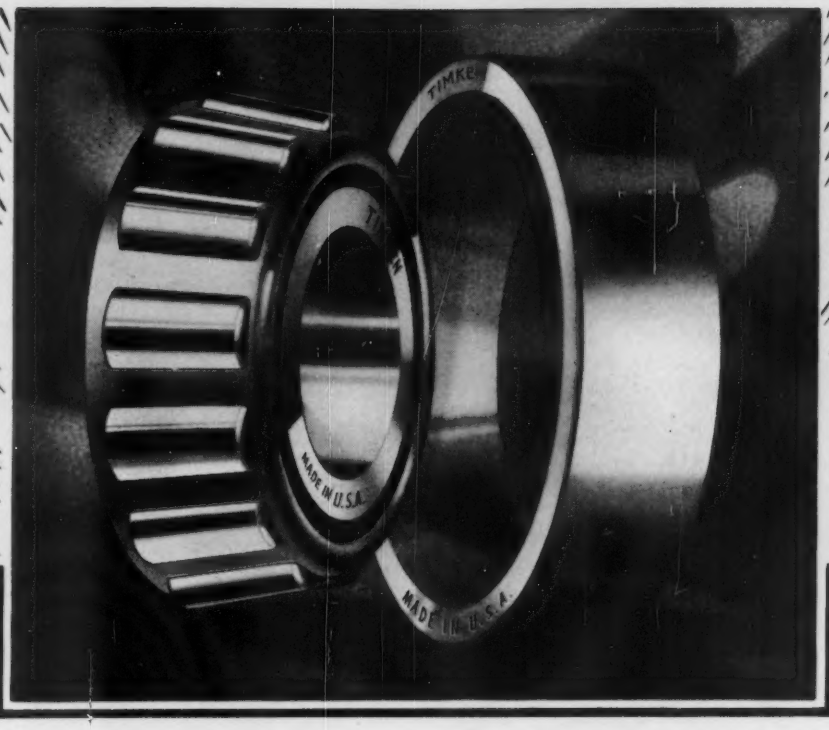
In addition to these activities research is being done on fundamental problems having some relation to the reduction of life and property losses.

All of this work has involved the examination of some 15,000 *different types* of devices, materials or systems submitted by more than 3,500 manufacturers. To date, after forty-five years of work, some 200,000 different catalog numbers or designs of products have been approved. This represents the investigation of a vastly greater number as approximately half the products sub mitted fail to pass the tests the first time. Some of these are, of course, redesigned and after two or more resubmittals are eventually approved. Others, however, are never returned to the Laboratories for a second investigation.

A manufacturer who submits a product to Underwriters' Laboratories pays for the examination and test of that product, whether the investigation leads to an immediate approval or results in a report outlining the respects in which the product failed to meet all of the requirements.

As the Laboratories is a non-profit organization established for service only, each job is charged for at a cost based on the salary-rate of the engineer assigned the investigation and the amount of time he spends on that particular job. There are no flat fees and each investigation is considered separately. The investigation of a simple type of attachment plug cap for plugging into an electrical outlet may run in the neighborhood of $15, while the cost of an initial investigation of the fire-resistance of a glass block wall or of a complex floor construction may be $2,000 or more.

For more than twenty years Underwriters' Laboratories has been self supporting. During its earlier years, however, the capital stock fire and casualty insurance



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Industry's Preference for Every Purpose

Industry's bearing problems constantly are increasing in number and importance due to the rapid developments and improvements in machinery of all kinds.

Speeds are going higher and higher. Operating loads—both radial and thrust—are becoming heavier and heavier. Working clearances of moving parts are getting closer and closer.

So in order to meet all modern requirements an anti-friction bearing must be able to do a lot more than eliminate friction. It must also be able to carry any load or combination of loads that are imposed on it—radial, thrust or both together—and at the same time hold shafts, gears and other vital moving parts in correct and constant alignment.

TIMKEN Tapered Roller Bearings have been doing all of these things—and doing them effectively—for more than 41 years. Today they are used in automobiles, motor trucks, trailers, streamlined trains and locomotives, steel rolling mills, precision machine tools—in fact wherever smoothness, accuracy and stamina must be assured.

TIMKEN Bearings are made by one of the world's outstanding engineering-manufacturing institutions . . . a large and financially strong organization with complete research, production and testing facilities, including the world's largest electric furnace steel capacity.

TIMKEN
TAPERED ROLLER BEARINGS

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish.
The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes; also cotton twines.
CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS **89 Broad Street, Boston 9, Mass.**

companies of the National Board of Fire Underwriters contributed generously to its support and today sponsor the work.

There are many reasons why manufacturers large and small in all parts of the country seek the approval of Underwriters' Laboratories for their products. Many manufacturers, desiring to make as reliable and satisfactory a product as is commercially practicable, see fit to give those products the "acid test" by having them reviewed not only by their own highly trained engineering departments, but also by a nationally recognized, unbiased, outside, technical organization. Then too, it is recognized that safety engineering of this kind is highly specialized, requiring much special test equipment, a technical staff experienced in the work, and standards by which the acceptability of the construction and performance of the products may be judged. In addition, having this work centralized results in a unification of requirements which is an obvious advantage to all concerned. Because of these factors and because of its long experience in this field, Underwriters' Laboratories' approval labels appearing on products have, through wide acceptance, come to have a well recognized value.

"But how are these products tested?" you are probably asking by now. Let us take a few specific examples.

One of the requirements of the Laboratories' standard on fire hose is that two and one-half inch diameter, double cotton jacketed, rubber lined hose — a type much used by municipal fire departments — should be capable of withstanding an internal pressure of 600 pounds per square inch without bursting. Also, when 400 pounds pressure is applied to this hose it should not elongate beyond a specified limit, should not twist more than a certain number of turns, or warp more than a specified number of inches out of a straight line.

What have these requirements to do with fire losses?

To cite an illustrative case, in the Atlanta, Ga. fire of 1917, more than fifty square blocks were lost principally because many lengths of hose burst under the water pressure.

Although fire departments rarely use as much as 250 pounds per square inch, the Laboratories' 600 pound requirement provides for an adequate factor of safety. Similar factors of safety are required wherever possible on many other types of products approved by Underwriters' Laboratories. The requirements for elongation, twist and warp have to do with ease of manageability of hose by firemen during a fire. One can readily imagine how fire fighting would be hampered if hose writhed and twisted like a snake when the pressure was applied or cut off.

These tests and many others are made at one of the Laboratories' testing stations during the initial investigation of a new design of fire hose, and, once approved, every length of hose which bears an Underwriters' Laboratories' label is first tested at the factory by one of the Laboratories' many field inspectors. Last year more than 400 miles of such fire hose were approved.

Each year approximately 916,000 miles of insulated electrical wire is produced which bears the Laboratories' label. Investigation of this wire for original approval of the design includes careful measurement of the cross sectional area of the copper conductors to determine their ability to carry the rated current of the particular size of wire without overheating. The thickness of the insulation must conform to the requirements for the type of wire and the conductor must be centered in the insulation so that there will be no thin spots through which there might be a breakdown to an opposite potential conductor or to grounded metal. Chemical tests are performed on the insulation to determine that the constituents of the compound are suitable and that the compound is satisfactory. Physical stretching and recovery tests of the insulation indicate its quality and its ability to "stand up" in years to come.

Not content to stop here the Laboratories' standard calls for accelerated ageing tests on wire in ovens and in the "oxygen bomb," an apparatus which will artificially age wire insulation in forty-eight or ninety-six hours the equivalent of somewhere between five and ten years of normal service.

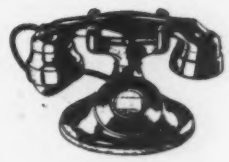
When it is realized that 25,000,000 homes in the United States are wired for electricity, to say nothing of the industrial and commercial premises, the value of this work may be somewhat appreciated, especially if the comparatively insignificant number of fires which result from wire failure is taken into consideration.

Space does not permit a lengthier description of the many requirements of the Laboratories' more than 150 sets of standards covering broad classifications of products. Perhaps its value to nearly every man, woman and child in the United States may be inferred from the fact that last year 500,000,000 individual articles were produced which carried the approval of Underwriters' Laboratories, and from the additional fact that this activity has been carried on with increasing volume for almost forty-six years.

A. FEIGENBAUM
Cameras and Lenses
Zeiss Equipment Our Specialty
Your camera taken in trade
46 BROMFIELD STREET, BOSTON
Telephone, Liberty 5762 Second Floor

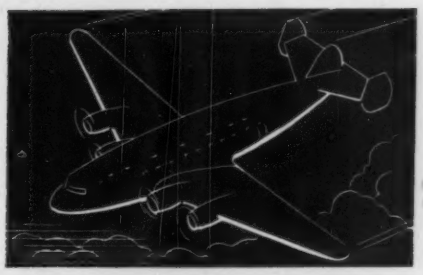
Your ears are our business

Western Electric makes—for the nation's ears—the telephones and the vast array of equipment necessary to provide Bell telephone service. Moreover, out of the telephone have come many other products which widen the hearing range of your ears—adding to public safety, convenience and pleasure. Here are some of these, made with the skill gained in seventy years' experience.



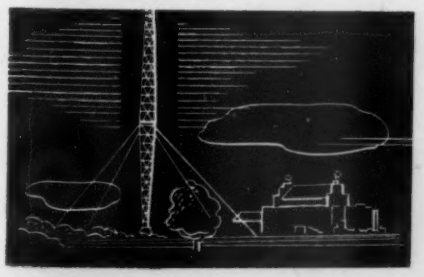
THE AUDIPHONE—based on techniques developed in Bell Telephone Laboratories—is helping many thousands with impaired hearing to hear clearly again. The Ortho-Technic model represents the most recent forward step in hearing aids.

THE FLYING TELEPHONE, which helps make possible today's splendid airline service, is the air-minded member of the family. All the major airlines and many private flyers now keep an ear to the ground with Western Electric equipment.



TALKING PICTURES, too, came out of telephone research. The principal producers and thousands of theatres use Western Electric sound apparatus for recording and reproducing pictures that entertain and instruct millions.

PUBLIC ADDRESS equipment, which widens the hearing circle at large gatherings, is another young brother of your telephone. It serves many purposes in hotels, schools, hospitals, auditoriums, stadiums, airports and amusement parks.



RADIO BROADCASTING is also an outgrowth of work in Bell Telephone Laboratories. More than 200 of this country's leading stations now use Western Electric equipment to put your favorite programs on the air.

POLICE RADIO—pioneered by the makers of your Bell telephone—is one of the law's most powerful weapons. Today Western Electric equipment is helping to increase arrests and decrease crimes—giving added protection to 45 million people.

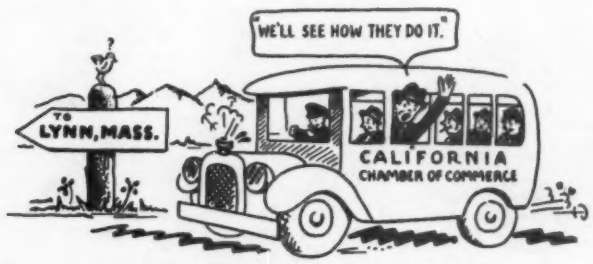
Western Electric *. . . made your* ***BELL TELEPHONE***

G-E Campus News

SIMPLIFIED BALANCING

HOW about balancing a 50-ton generator rotor turning at 3600 rpm? No, not on the end of your chin or anything like that, but balancing it until its vibration is less than three ten-thousandths of an inch—or one-tenth the diameter of a human hair! Not so easy, you say? Well, a little while ago you would have been right, for the balancing of a large rotating machine was a long-drawn-out procedure, perhaps requiring the removal of the rotor from the machine.

But today there is a G-E portable instrument that does the job simply, quickly, and under actual operating conditions. A 20,000-kva synchronous condenser, for example, can sometimes be balanced in as few as three runs—a far cry from the 100 to 170 trials which were frequently necessary before.



WEATHER MAKERS

CALIFORNIA'S weather has always been a source of pride to the natives, but, when it comes to actually making the weather conditions you want, the G-E engineers at the West Lynn Works are in a class by themselves.

These engineers produce temperatures ranging from 40 below zero F to 160 above and a humidity of 100 per cent if so desired. But they really aren't trying to compete with California. The excuse for all this weather-making is the testing of watthour meters. For G-E engineers want to be sure the meters are capable of accurately recording the amount of electric energy consumed under varying conditions of temperature and humidity.

To insure this, the meters are tested at temperatures more extreme than they would ever normally encounter and in atmospheres saturated with moisture. Such tests, made by young college-trained engineers, assure reliability.

THIRD GENERATION

GENERAL Electric became a proud grandfather this year, when Charles E. Wilson became president and Philip D. Reed chairman of the board of directors—the third generation of G-E leaders. They will carry on as "captain" and "navigator" of General Electric in place of Gerard Swope and Owen D. Young, who held these positions from 1922 until their retirement at the first of this year.

Mr. Young and Mr. Swope leave behind them a brilliant record of achievement. Under their leadership General Electric fostered a great new branch of the electrical industry—the manufacture of appliances which eliminate the drudgery of housework and create comforts and conveniences for the home.

Through their efforts General Electric's many employee plans were achieved—old-age pensions and group life insurance, a wage-adjustment plan to meet increases in the cost of living, vacations with pay, an employee savings plan and many others—ample evidence that these executives were many years ahead of their time in vision and consideration for the welfare of their employees.

GENERAL ELECTRIC

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The Murray Printing Company
Kendall Square, Cambridge